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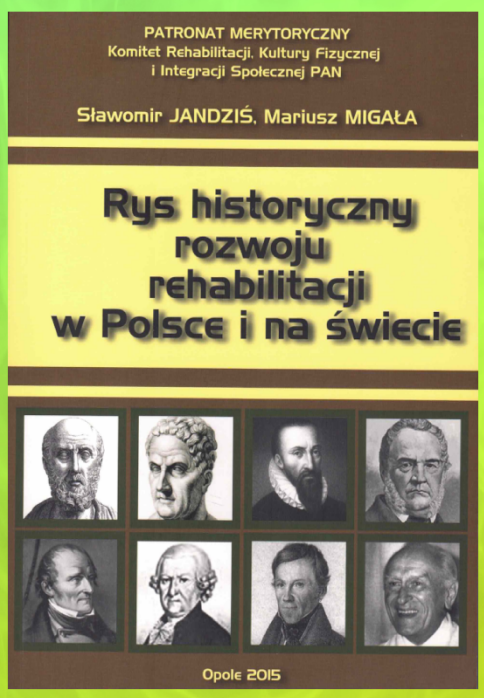

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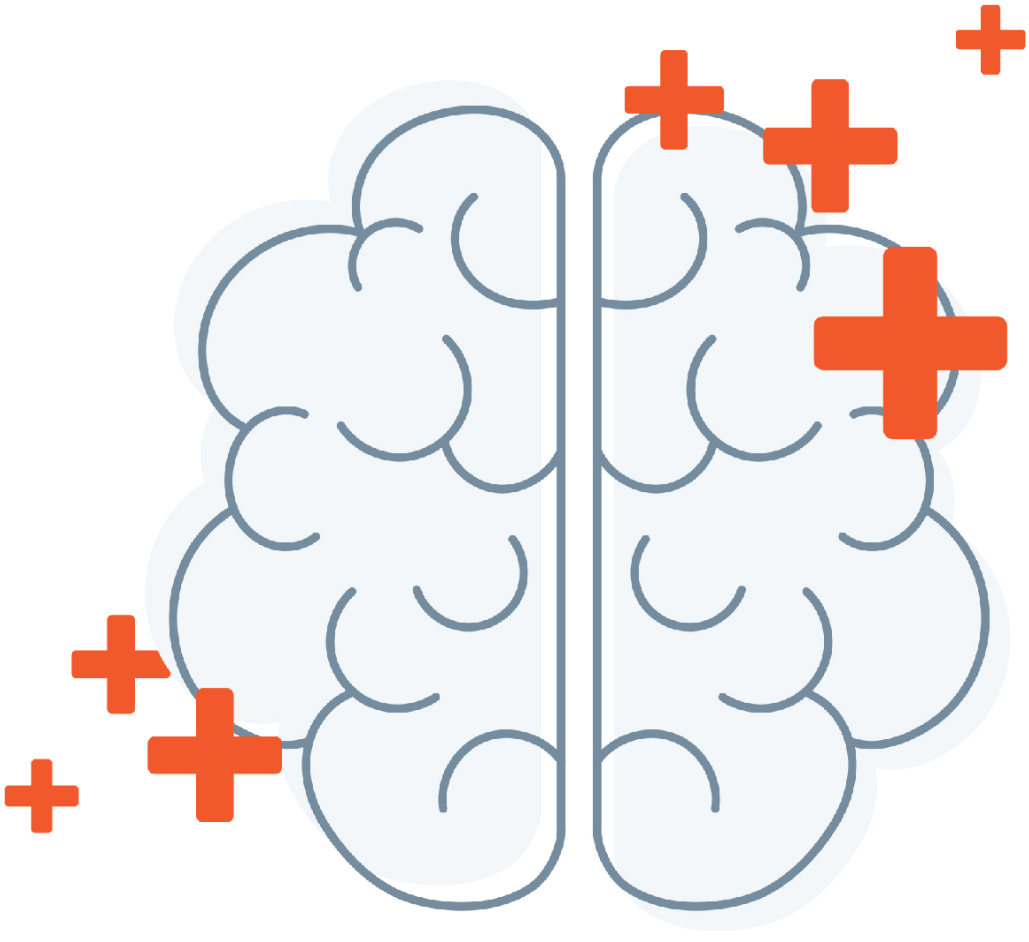

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Effect of incentive spirometry on pulmonary function test in post COVID-19 pneumonia patients

Wpływ spirometrii bodźcowej na test czynnościowy płuc u pacjentów z zapaleniem płuc po COVID-19

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Abstract

Background. COVID-19 caused by SARS-CoV-2 virus was assigned as a pandemic by WHO. Fever, breathlessness, cough and expectoration indicates lung involvement in the form of pneumonia and its most common complications are pulmonary fibrosis, chronic respiratory failure and reduced quality of life. Incentive spirometry is the relevant therapy to enhance the normal lung function and improve quality of life. Aim. To find the effect of incentive spirometry on pulmonary function test in post COVID-19 pneumonia patients. Methodology. An experimental study with simple random sampling (lottery method) of 24 patients in age group (18-68 years). The participants were randomly divided into 2 groups. Group A received pharmacotherapy and incentive spirometry and Group B received only pharmacotherapy. Computerized spirometry and Diffusion lung capacity for carbon monoxide (DLCO) was used as diagnostic tool to measure pre & post test values for both groups. Intervention was given for 4 weeks and after 4 weeks, to analyze the spirometry values post-test was taken for both groups. Outcome measures. Forced expiratory volume in the first second (FEV1), Forced vital capacity (FVC), FEV1/FVC &DLCO. Results. Statistical analysis shows significant improvement ($p < 0.05$) between pretest and post test values on Pulmonary Function Tests (PFT) in both Group A&B whereas there was increase in the improvement in intervention group than control group. Conclusion. Incentive spirometry improved the lung volume and capacities on PFT in post COVID-19 pneumonia patients and also these patients have mainly restrictive lung pattern by the use of DLCO.

Keywords

FEV1, FVC, FEV1/FVC, DLCO, post COVID-19 pneumonia patients, incentive spirometry

Streszczenie

Wprowadzenie. COVID-19 wywołany wirusem SARS-CoV-2 został uznany przez WHO za pandemię. Gorączka, duszność, kaszel i odkrztuszanie wskazują na zajęcie płuc w postaci zapalenia płuc, a jego najczęstszymi powikłaniami są zwłóknienie płuc, przewlekła niewydolność oddechowa i obniżona jakość życia. Spirometria bodźcowa jest odpowiednią terapią poprawiającą prawidłową czynność płuc i jakość życia pacjentów. Cel. Zbadanie wpływu spirometrii bodźcowej na wynik czynnościowy płuc u pacjentów z zapaleniem płuc po COVID-19. Metodologia. Badanie eksperymentalne metodą wyrywkową objęło 24 pacjentów w grupie wiekowej (18–68 lat). Uczestnicy zostali losowo podzieleni na 2 grupy. Grupa A otrzymywała farmakoterapię i była poddawana spirometrii bodźcowej, a grupa B otrzymywała jedynie farmakoterapię. Skomputeryzowana spirometria i pojemność dyfuzyjna płuc dla tlenku węgla (DLCO) zostały użyte jako narzędzie diagnostyczne do pomiaru wartości przed i po interwencji dla obu grup. Interwencję prowadzono przez 4 tygodnie, a po 4 tygodniach w celu analizy wartości spirometrycznych wykonano badanie dla obu grup. Miary wyników. Natężona objętość wydechowa w pierwszej sekundzie (FEV1), Natężona pojemność życiowa (FVC), FEV1/FVC &DLCO. Wyniki. Analiza statystyczna wykazuje znaczną poprawę ($p < 0,05$) między wartościami testów czynnościowych płuc (PFT) przed i po interwencji w obu grupach A i B; większą poprawę zaobserwowano w grupie badanej niż w grupie kontrolnej. Wniosek. Spirometria bodźcowa poprawiła objętość płuc i czynności płuc w PFT u pacjentów z zapaleniem płuc po COVID-19. U pacjentów z zapaleniem płuc po COVID-19 zmiany widoczne w badaniu DLCO mają głównie charakter restrykcyjny.

Słowa kluczowe

FEV1, FVC, FEV1/FVC, DLCO, pacjenci po zapaleniu płuc po COVID-19, spirometria bodźcowa

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Introduction

The outbreak of pneumonia with unexplained cause was discovered in Wuhan city, china on December 2019 that later be identified as severe acute respiratory syndrome corona virus 2 (SARS-CoV-2) [1]. Corona virus disease 2019 (COVID-19) which belongs to the family of SARS-CoV-2 virus assigned as a pandemic on 11 march, 2020 by the World Health Organization (WHO). This virus gets in a high degree of propagation by respiratory droplets through coughing and sneezing from direct, indirect or mutual contact with infected people [2]. The pandemic COVID-19 had been outspread to 219 countries and the incidence was greater than 608 million with the death cases of greater than 6.50 million people were reported around worldwide. In India 44.52 million cases and death of 528,273 were recorded by the time of 16 September 2022 which reveals that COVID-19 was a potentially fatal life threatening disease [3].

The infection of lung parenchyma (respiratory bronchioles and alveoli) causes the small air sacs to be filled with fluid or suppuration which defines Pneumonia. The accumulation of fluid is caused by microorganisms (bacteria, virus, fungi) when it enters the lower respiratory tract creates more complications in the lung [4]. Pneumonia ranges from mild illness, moderate pneumonia to severe pneumonia. COVID-19 pneumonia occurs when the infection of the respiratory droplets containing SARS-CoV-2 virus enters the lower respiratory tract. This may prone to respiratory failure in the affected individuals [5]. According to the statement from WHO the clinical manifestation of febrile, Breathlessness, cough expectoration, chest tightness, malaise, myalgia, anorexia indicates the lung involvement in the form of pneumonia leading to Acute Respiratory Distress Syndrome (ARDS) and its most common complications are pulmonary fibrosis, chronic respiratory failure and reduced quality of life [6]. CT chest imaging findings of multifocal symmetrical Ground Glass Opacities (GGO) generally with sub pleural and peripheral representation confirms the covid-19 pneumonia [7].

British Thoracic Society (BTS) guidance specifically remarked that Respiratory monitoring for the recovered COVID-19 pneumonia is essential to determine the possibility of fibrosis in the lung which could leads to decrease the lung volume and capacities. Earlier medical and physical rehabilitation management is highly necessary for these patients [8]. To improve the decreased lung function on the post COVID-19 pneumonia which used incentive spirometry exercises [9]. Incentive spirometry (sustained maximal inspiration) increase the lung volumes & capacities, reinflates the areas of collapsed lungs and strengthen the respiratory muscles [10].

Pulmonary Function Test is the standard method to assess lung volumes and functions both in physiological and pathological conditions. Spirometry and DLCO was used in this study to find the extent of lung damage in the post COVID-19 pneumonia patients. Spirometry is the most common lung function test used to measure the ventilatory function and for examining the patients with pulmonary disease increase the lung volumes [11]. Diffusion lung capacity for carbon monoxide (DLCO) is a diagnostic tool to differentiate obstructive and restrictive lung disease. It accurately measures the amount of gaseous exchange in small air sacs alveoli with pulmonary capillaries. DLCO < 80% of predicted value was considered as Diffusion deficit [12]. The PFT was performed to the COVID-19 pneumonia patients with the recovery of 8 weeks from the European Respiratory Society (ERS) guidelines statement that Pulmonary function tests (PFT) should not be perform within 1-month discharge. Spirometry values like FVC, FEV1, FEV1/FVC and DLCO were performed in this study [13].

Aim

The study aimed to assess the pulmonary function test (spirometry & DLCO) in post COVID-19 pneumonia patients and improvement of the same after 4 weeks using incentive spirometry. There was a lack of studies in worldwide to implement the incentive spirometry with pulmonary function tests in post COVID-19 pneumonia patients and is worth noting that evidence about pulmonary function test among COVID-19 pneumonia patients with 4 weeks incentive spirometry intervention can improve prognosis, maximize functional capacity and quality of life.

Materials and methods

The study was experimental, pre and post test type with simple random sampling method conducted among 24 post COVID-19 pneumonia patients in the Respiratory Medicine Department for a duration of 4 weeks. This study includes the post covid-19 pneumonia patients (recovery of 2 months), age 18–68 years, both men and women and the patients having mild (0–5), moderate (6–15) illness in the CT severity score. 24 samples was taken by the Simple random sampling in lottery method. The study excludes the pneumonia with CT severity score more than 15, severe dyspnea, respiratory distress, active hemoptysis, known COPD, bronchial asthma, pulmonary tuberculosis, recent myocardial infarction, recent abdominal & thoracic surgery, recent rib fracture and trauma to chest, pneumothorax, patients with active smoking habits and uncooperative patients. Patients with comorbidities like diabetes, hypertension, BMI above 30 (obesity) value according to WHO were excluded.

Institutional Ethical Committee (IEC) was approved the study from the SRM Medical College Hospital & Research Centre (Ethics Clearance No: 2384/IEC/2021). The subjects were selected based on their inclusion and exclusion criteria and the demographic data was collected from them. An informed written consent was obtained from the patients after a detailed explanation of the procedure. This study was double blinded study while doing the procedure. As per the guidelines, pulmonary function tests (computerized spirometry & DLCO) were performed on the post COVID-19 pneumonia patients after the detailed examination done by the pulmonologist. Patients blood pressure, pulse, SPO_2, BMI and the spirometry values like Forced vital capacity (FVC), Forced expiratory volume in the first second (FEV1), FEV1/FVC and Diffusing Capacity of the lungs for Carbon monoxide (DLCO) was measured at the time of presentation. All the values were collected and analysed. 24 patients with abnormal spirometry and DLCO parameters were randomly allotted into Group A (intervention) who underwent pharmacotherapy (antifibrotic agents-Pirfenidine dosage (200–800 mg) three times/day, Nintedanib (100–200 mg) once a day) and incentive spirometry and Group B (control) who underwent pharmacotherapy only. Pulmonary function test was performed for these patients by the respi-

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ratory therapist. The procedure was followed by the ATS-ERS guidelines [14] and the safety precautionary measures was taken considering the present pandemic context. The pulmonary function tests have been taken after the 4 weeks of exercise intervention for both the groups and both the values were compared.

Procedure for Group A (intervention group)

Incentive spirometry (flow oriented) was taught to the patients in right side-lying position with hands on the contralateral costal segment and vice versa. Demonstration of procedure to the patient is important to make sure that they understood the technique before doing it. Instructions to the patients were placing lips in the mouthpiece of spirometry which be held in upright position. The therapist gave an explanation of inspiratory flow inhale slowly and deeply as the balls raise, the patients had to get the balls as high as possible and hold the breath for 5 secs and then exhale normally. Flow oriented incentive spirometer has 3 volumes (600 cc, 900 cc, 1200 cc). The patients were encouraged to raise all the three balls and sustain the maximal inspiration for 5 seconds as it provides positive visual feedback to them [15].

The exercise protocol for both the exercises had been charted out for 4 weeks duration, 3 sets of 5 repetitions /session and do this exercise for every 2 hrs/once in awaken hours for the rest of the day. The patients were instructed to follow up these exercises and maintain a log note record for the same [16].

Figure 1. Incentive spirometry exercise position

Statistical analysis

Data obtained was analyzed statistically using SPSS Software for windows 10 version 20. The statistical tool of paired 'T' test was used to compare the pre and post test on pulmonary function test for both Group A&B post Covid-19 pneumonia patients and the Independent sample 'T' test was used to compare post test Group A&B patients.

Results

A total of 24 post Covid-19 pneumonia patients (men – 16, women – 8) were included in this study. Table 1 shows the Group A mean and standard deviation value of age 37.33 ± 8.07 years, CT severity score value 10.25 ± 3.79, height (cm) 163.8 ± 39.42, weight (kg) 69.75 ± 10.49, BMI 26.12 ± 4.30, and in Group B age is 36.67 ± 10.24 years, CT severity score value 10.50 ± 3.70, height (cm) 168.25 ± 6.52, weight (kg) 73.92 ± 8.87, BMI 26.20 ± 3.65.

Table 2 and Figure 2 for Group A patients shows statistically significant improvement ($p < 0.05$) from the pretest value in FVC 69.58 ± 4.27 to post-test value 80.25 ± 3.14. Similarly, the statistically significant improvement ($p < 0.05$) from the pretest value in FEV1 71.50 ± 4.77 to post test value 85.00 ± 5.06

Table 1. Demographic data

Characteristics	Group A	Group B
Men (N)	8	8
Women (N)	4	4
CT severity score (Mean ± SD)	10.25 ± 3.79	10.50 ± 3.70
Age [years] (Mean ± SD)	37.33 ± 8.07	36.67 ± 10.24
Height [cm] (Mean ± SD)	163.83 ± 9.42	168.25 ± 6.52
Weight [kg] (Mean ± SD)	69.75 ± 10.49	73.92 ± 8.87
BMI [kg/m^2] (Mean ± SD)	26.12 ± 4.30	26.20 ± 3.65

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FEV1/FVC from 102.42 ± 1.31 to 105.42 ± 3.32 and in DLCO from 45.75 ± 7.02 to 60.25 ± 8.07.

Table 3 and Figure 3 for Group B patients shows statistically significant improvement ($p < 0.05$) from the pretest value in FVC 67.8 ± 5.6533 to post-test value 71.75 ± 5.34 similarly, the statistically significant improvement ($p < 0.05$) from the pretest value in FEV1 70.6 ± 5.74 to post test value 75.00 ± 6.01 and in DLCO from 46.00 ± 4.37 to 50.00 ± 3.86. In FEV1/FVC the pretest value from 103.83 ± 2.66 to post-test value 104.08 ± 3.02 shows that there was an improvement but it was not statistically significant ($p > 0.05$).

Table 4 and Figure 4 shows statistically significant improvement ($p < 0.05$) in post-test value FVC in Group A 80.25 ± 3.14when compared to Group B 71.75 ± 5.34. Similarly, statistically significant improvement ($p < 0.05$) in post-test value of FEV1 in Group A 85.00 ± 5.06 when compared to Group B 75.00 ± 6,02 and in DLCO post test value for Group A was statistically improved 60.25 ± 8.07 when compared to Group B 50.00 ± 3.86. In FEV1/FVC post-test value for Group A 105.42 ± 3.31 when compared to Group B 104.08 ± 3.03 there was an improvement but it was not statistically significant ($p > 0.05$).

Table 2. Comparison of pre and post test of pulmonary function test in group A

Variables	N	Test	Mean	SD	Mean diffrence	t-statistic (df)	p-value
FVC (L%)	12	Pre Post	69.58 80.25	4.27 3.14	−10.67	−10.48	0.001
FEV1 (L%)	12	Pre Post	71.50 85.00	4.77 5.06	−13.50	−12.71	0.001
FEV1/FVC	12	Pre Post	102.42 105.42	1.31 3.32	−3.00	−3.76	0.003
DLCO (ml/min/mmHg%)	12	Pre Post	45.75 60.25	7.02 8.07	−14.50	−6.86	0.001

(p < 0.05) statistically significant*

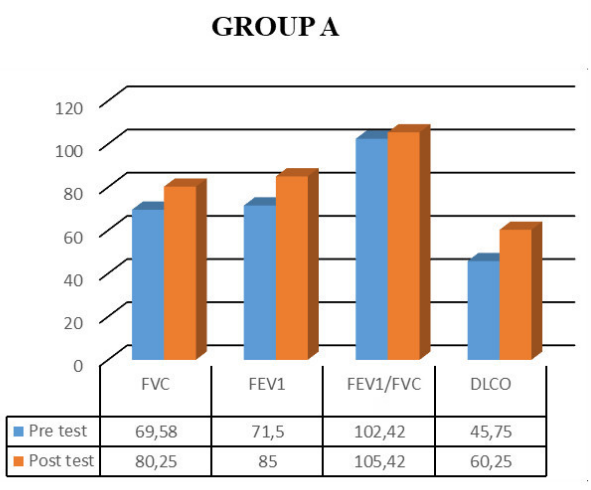

Figure 2. Comparison of pre and post test of pulmonary function test in group A

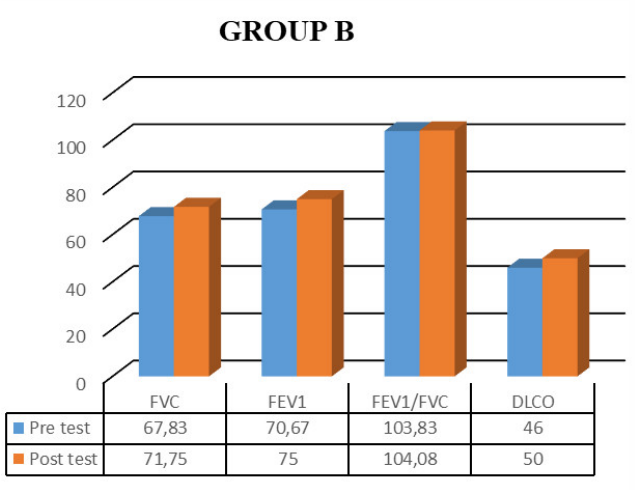

Figure 3. Comparison of pre and post test of pulmonary function test in group B

Table 3. Comparison of pre and post test of pulmonary function test in group B

Variables	N	Test	Mean	SD	Mean diffrence	t-statistic (df)	p-value
FVC (L%)	12	Pre Post	67.83 71.75	5.65 5.34	−3.92	−6.31	0.001
FEV1 (L%)	12	Pre Post	70.67 75.00	5.91 6.01	−4.33	−8.22	0.001
FEV1/FVC	12	Pre Post	103.83 104.08	2.66 3.02	−0.25	−0.25	0.809
DLCO (ml/min/mmHg%)	12	Pre Post	46.00 50.00	4.37 3.86	−4.00	−6.49	0.001

(p < 0.05) statistically significant*

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Table 4. Comparison of post test on pulmonary function test between group A and group B post Covid 19 pneumonia patients

Variables	N	Test	Mean	SD	Mean diffrence	t-statistic (df)	p-value
FVC (L%)	12	Group A post Group B post	80.25 71.75	3.14 5.34	8.50	4.75	0.001
FEV1 (L%)	12	Group A post Group B post	85.00 75.00	5.06 6.02	10.00	4.40	0.001
FEV1/FVC	12	Group A post Group B post	105.42 104.08	3.31 3.03	1.33	1.03	0.315
DLCO (ml/min/mmHg%)	12	Group A post Group B post	60.25 50.00	8.07 3.86	10.25	3.97	0.001

(p < 0.05) statistically significant*

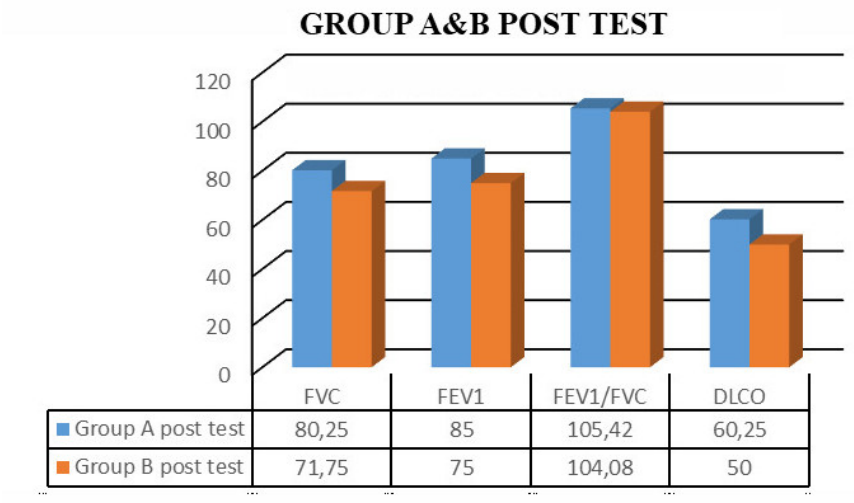

Figure 4. Comparison of post test on pulmonary function test between group A and group B post Covid 19 pneumonia patients

Discussion

The main aim of the present study was to determine the effect of lung expansion therapy on pulmonary function test in post COVID-19 pneumonia patients. Spirometry of (FVC, FEV1, FEV1/FVC) and DLCO were taken as the outcome measure for the pretest and post test evaluation. All the patients were selected randomly and equally divided into two groups according to the inclusion and exclusion criteria. The intervention of Incentive spirometry for Group A patients was given for 4 weeks as the form of pulmonary rehabilitation. The recent research findings of I. Saab et al., who reported that the main CT feature of COVID-19 pneumonia was the presence of ground glass opacities (GGO) with peripheral dominance [7]. This is consistent with the present findings where the GGO was the common findings, from which the mild and moderate illness patients were taken for intervention.

Jain W et al., concluded that there were evident changes on the pulmonary function tests in the post COVID-19 patients which is in harmony with the present study. This study recommends incentive spirometry exercise as the intervention for the post COVID-19 patients [17]. whereas, there was a limited study to explore the outcome for this intervention. The present study shows the effective improvement in the intervention for post COVID-19 pneumonia patients.

Peter M George et al., discussed the importance of PFT in the post COVID-19 pneumonia patients for the early detection and prognosis of interstitial lung disease [18]. Mickey Lui et al., found the early implementation of pulmonary rehabilitation restores the normal lung functions and prevents the severity of the disease in the affected individuals [9]. From these findings the current study was conducted to evaluate the changes on PFT and the effect of incentive spirometry for the post COVID-19 pneumonia patients.

American Thoracic Society (ATS)/European Respiratory society (ERS) guidelines stated, decreased FVC < 80% predicted value, decreased FEV1 < 80% predicted value, decreased DLCO < 80% predicted value and normal or increased FEV1/ FVC ≥ 75% predicted values confirms the restrictive ventilator defect [12, 19, 20]. Similarly, the present findings shows the decreased FVC, FEV1, DLCO and normal or increased FEV1/ FVC predicted values in both the Group A and Group B patients which proves the restrictive ventilatory deficit in post COVID-19 pneumonia patients. Daniele Colombo et al., findings suggest that COVID-19 pneumonia patients have lung function test changes with mainly restrictive pattern using spirometry [21] Similarly, this study identifies the lung function alterations and it also provides the evidence for restrictive lung pattern in the patients using the DLCO.

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Computerized spirometry was used for diagnosing and assessing the lung disease in post COVID-19 patients and in DLCO single-breath hold technique was used to measure the capable of gaseous exchange between the alveoli and pulmonary capillaries. Gaseous exchange in alveolar capillary membrane usually travels through thin layer in the lungs wherein restrictive lung this membrane becomes scared and thickened which reduce the diffusion of gas across the membrane results in decreased DLCO [22, 23].

Elizabeth Dean et al., clearly explained the physiology of body positioning in side lying position where the V/Q ratio was optimal results in increased ventilation & gaseous exchange, decreased resistance to work of breathing when compared to supine position [24]. From this suggestion, the incentive spirometry was performed in side-lying position for the patients which increase the efficiency in exchange of gases.

The present findings of mean and SD values like FVC, FEV1, FEV1/FVC & DLCO in the Group A patients were improved from the pretest to post-test and statistically significant ($P < 0.05$). Ying Chen et al concludes that six-minute walk test and respiratory muscle training exercises as the respiratory rehabilitation which improves the respiratory function in the elderly covid-19 patients [25]. Whereas in this study, incentive spirometry exercises was performed and there was an significant improvement in the respiratory function for post covid-19 pneumonia patients. Freitas et al., & Erickson T et al., suggested that incentive spirometry & deep breathing exercises were used to prevent the postoperative pulmonary complications like, pneumonia and respiratory failure, atelectasis after cardiothoracic surgery [26]. From this knowledge, the present study used the incentive spirometry in post COVID-19 pneumonia patients to prevent pulmonary complications.

Patrick Huppmann et al., proved that respiratory physiotherapy plays a major role in pulmonary rehabilitation for Restrictive lung disease and improves the lung function and quality of life in the affected individuals [27]. With analogy, the present study shows the effect of incentive spirometry for the post COVID-19 pneumonia patients where the restrictive lung pattern was noticed in them.

After 4 weeks intervention, Group A and Group B patients mean and SD values shows statistically significant improvement within the groups. But Group A mean and SD values determines the statistically significant ($p < 0.05$) improvement in FVC, FEV1, DLCO was higher than in Group B. Hence this study concludes that there was significant effect of incentive spirometry on Pulmonary function tests in the post COVID-19 pneumonia patients. Allan J. Walkey explained the physiological response to pneumonia infection in which the innate or natural immunity of immune resistance and resilient tissue is the defense protective mechanism against the lung infection. Cells residing in the lung provokes the response with additional immunity effectors of natural killer cells, macrophages and neutrophils which was essential for the clearance of viral and bacterial pneumonia [28]. In accordance with this physiology, in the Group B patients the mean and SD values were improved from the pretest to post test values and it was statistically significant. The post test value of FEV1/FVC for Group A patients when compared to Group B there was clinical improvement, but it was not statistically significant ($p > 0.05$).

Shyam Krishnan et al., concluded that a mechanical device of incentive spirometry encourage the long, slow, sustained deep inspiration to achieve maximal inflating pressure in the alveoli and improves the inspiratory muscle strength [29]. Tomas Eriksson et al., & Adi Dagan et al found that chest physiotherapy (Incentive Spirometry and deep breathing exercises) enhance the lung inflation to prevent atelectasis, clears the fluid filled up in pneumonia [30]. In the similar manner, Incentive spirometry was used in this study and there was an evident improvement in the post covid-19 pneumonia patients. Future study on respiratory follow-up of the post covid-19 pneumonia patients and long-term pulmonary rehabilitation could be helpful to prevent the pulmonary complications and improve the quality of life.

The study has the following limitations of small sample size and short follow-up time. Therefore, studies in large samples with long term follow-up are needed to confirm it. This study recommends other techniques such as six-minute walk test, respiratory muscle endurance training and resistance band training can be included in the exercise program for post COVID-19 patients to improve the health status.

Conclusion

This study concludes that there is significant effect of incentive spirometry on pulmonary function test in the post COVID-19 pneumonia patients. This study also concludes that these patients have restrictive lung pattern in DLCO findings and significantly improved with incentive spirometry.

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